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INVESTIGATION OF FORGED AND CAST BRASS

(MATERIAL SECTION REPORT NO. 158)

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INVESTIGATION OF FORGED AND CAST BRASS.

PURPOSE.

To determine the suitability of forged brass in gasoline pipe line and tank fittings for service use on airplanes.

To compare the soundness of forged and cast brass fittings.

CONCLUSIONS.

Forged brass fittings are recommended for service use on airplanes where parts are standardized and can be ordered in quantity. For other than a production basis, the cost of forged brass parts would be prohibitive as compared to the sand cast.

Forged brass has a greater tensile strength, is harder, and less porous than cast brass.

MATERIAL.

The following brass forgings submitted by the Mueller Metal Co., Port Huron, Mich.:

Specimen No.	Part.
1	Forged brass cylinder plug, manufactured by the Delco Light Co.
2	Forged brass sediment bowl, manufactured by the Michigan Stamping Co.
3	Forged brass flared tube and nut, manufactured by the Olds Motor Works.
4	Forged brass elbow, manufactured by the White Motor Co.
5	Forged brass vacuum elbow, manufactured by the Olds Motor Works.

The following fittings made in the Metals Branch Foundry in addition to several metallographic samples taken from routine foundry melts of gun metal:

Specimen No.	Part.
6	Cast brass [illegible]-inch elbow.
7	Cast brass [illegible]-inch T.

Specimen No. 8 was selected at random from the stockroom.

PROCEDURE.

CHEMICAL ANALYSIS.

The outline of procedure was to determine the chemical composition of specimens Nos. 2 and 4 which were submitted by the Mueller Metal Co. The chemical composition of specimens Nos. 6 and 7, which were cast in the Metals Branch Foundry, were obtained from the foundry record of the melts from which these parts were cast. The composition of the fitting obtained from stock was not determined.

METALLOGRAPHIC.

All specimens were prepared for examination according to standard practice and etched with NH_4OH and H_2O_2. Specimens from forged brass were taken parallel and at right angles to direction of forging. The polished but unetched specimens were carefully examined for blowholes, segregates of oxides and other impurities. Microphotographs were made of representative specimens. Specimen No. 2 was annealed for 2 hours at 1400 deg. F. and allowed to cool with the furnace in order to determine if the forged brass had been subjected to an anneal subsequent to forging.

PHYSICAL TESTING.

Scleroscope hardness tests were made on all specimens and Brinell hardness was obtained on specimens Nos. 1, 2, and 8. Material for strength test was not available.

STRAIN TEST.

Specimens were first subjected to a preliminary treatment by immersing for five seconds in a 5 per cent aqueous solution of HNO_3 and then pickled for five hours in a 0.1 per cent solution of mercurous nitrate ($HgNO_3$) in water.

RESULTS.

The results of the chemical analysis are depicted in Table I.

TABLE I.

Specimen No.	Tin.	Lead.	Copper.	Zinc.	Iron.
1			(1)		
2	0.30	2.76	57.88	Diff.	0.31
3			(1)		
4	.47	2.35	59.00	Diff.	.37
5			(1)		
6	9.87	Nil.	88.40	1.30	.16
7			(1)		
8			(1)		

[1] Not determined.

METALLOGRAPHIC.

Representative micrographs are shown in figures 669-1 to 669-8, inclusive. The structure of the material submitted by the Mueller Metals Co. (figs. 669-1 to 669-5, inclusive), resembles that of extruded Muntz metal. The irregular orientation of the alpha and beta structure shows the effects of the forging. This is more pronounced in sections that have been subjected to more work than others, such as the portion adjacent to the point of minimum radius of curvature in the forged elbows (see fig. 669-2). There is no indication in the microstructure of cold work. The annealed specimen showed frequent

twinning of the alpha constituent. The lead in these specimens could easily be distinguished at a magnification of 500 diameters and is evenly distributed through both the alpha and beta structures. The forged specimens were free from blowholes, cold shuts, and segregations of foreign matter.

The structure of the material cast in the Metals Branch Foundry is typical of cast gun metal. The dark cores are the copper rich alpha solution, and the small light areas, readily seen at a magnification of 500 diameters, are the alpha delta copper-tin constituent (see figs. 669–6 and 669–7). Blowholes could be distinguished in the unetched specimens. In some they were quite numerous, others quite rare. In a few cases there was evidence of inclusions of oxides in the specimens taken from routine foundry melts.

The structure of the fitting taken from stock indicates that the brass used was high in lead and very much inferior to either material used by the Mueller Metal Co. or the Metals Branch Foundry. There is evidence of segregation or liquation of the lead along the grain boundaries. Specimen which was annealed for two hours at 1,400° F. showed frequent twinning of the alpha constituent.

PHYSICAL TESTING.

Results of the hardness tests are given below in Table II.

TABLE II.

Specimen No.	Part.	Scleroscope.	Brinell.
1	Cylinder plug	23	98
2	Sediment bowl	18	80
3	Flared tube and nut	26	....
4	Elbow	29	....
5	Vacuum elbow	21	....
6	Cast elbow	22.7	70
7	Cast T	19	65
8	Cast T (stock)	14	....

STRAIN TEST.

Results of the strain test were negative in all cases. After five hours' immersion in the mercurous nitrate solution, the specimens were evenly coated with metallic mercury, but there were no signs of cracks.

DISCUSSION OF RESULTS.

The chemical analysis shows that the metal used in the forgings is of the Muntz metal type and is within the range of composition recommended for hot forgings or stamping by Guillet. Although the manufacturer claims that the forging of brass is a new process, brass has been successfully hot forged or stamped in England for several years. It is known that there is danger of producing internal strains which result in season or spontaneous cracks. This condition is usually caused by forging at too low a temperature and can be readily detected in either the microstructure or by the mercurous nitrate test. Unless the cold work has been too severe, it may be remedied by annealing at a temperature ranging 600° to 800° F. The twinning of the alpha constituent in the annealed specimen indicates that this material has not been annealed subsequent to the forging operation. Another source of trouble encountered by the use of forged brass is the unequal hardness of different lots of metal which seriously slows up the speed of machining when the parts are being turned out on production basis. The variation in hardness is usually contributed to the chemical composition and so can be controlled. The hardness tests and the chemical composition of the forged fittings under test indicate that fittings made of this material could be readily machined.

It may be observed that the fittings cast in the Metals Branch Foundry are of tin bronze and not brass. The reason for this is that although the copper-tin alloy is more expensive, it gives a sounder casting and is more desirable for parts that are to hold water or gasoline. For that reason the gun metal rather than the red brass cast in Metals Branch Foundry was taken as a basis with which to compare the forged brass. The properties of forged and cast brass are not really comparable, as the effect of either hot or cold work on a metal is well known, and it is to be expected that the forged material would be far superior to the cast. The particular forgings under test were forged from extruded bars so that the product is a result of two processes of hot working along with the necessary annealing, all of which tends to produce a material more homogeneous and sound than that which is used in the final product as cast.

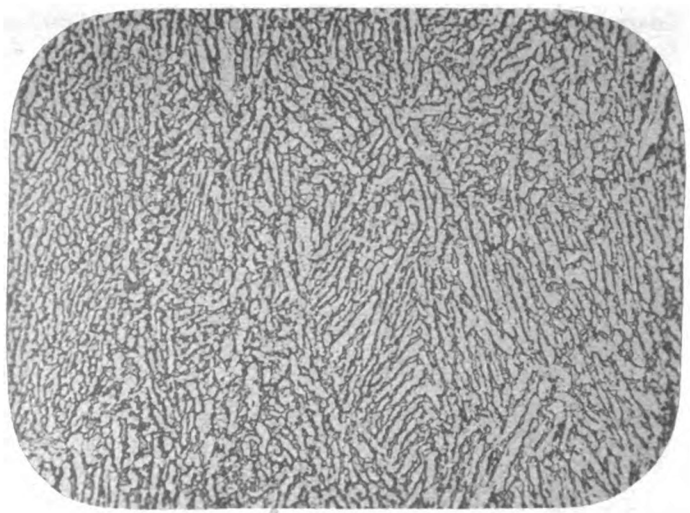

FIG. 669-1.—Magnification 100 diameters. Etching $NH_4OH+H_2O_2$. Remarks: Section from specimen 3.

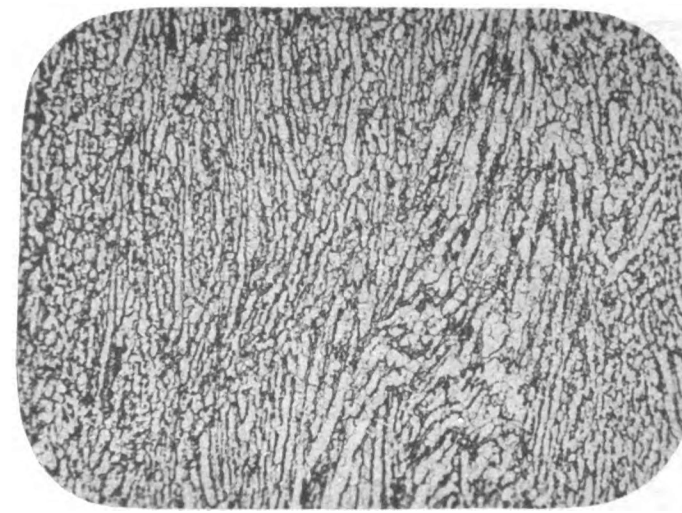

FIG. 669-2.—Magnification 100 diameters. Etching $NH_4OH+H_2O_2$. Remarks: Section taken from specimen 3 at the point of maximum radius of curvature.

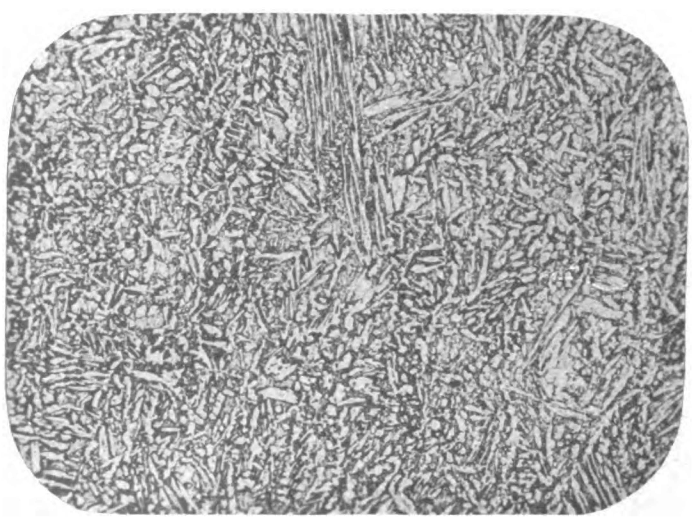

FIG. 669-3.—Magnification 100 diameters. Etching $NH_4OH+H_2O_2$. Remarks: Section taken from specimen 2 at right angles to direction of forging.

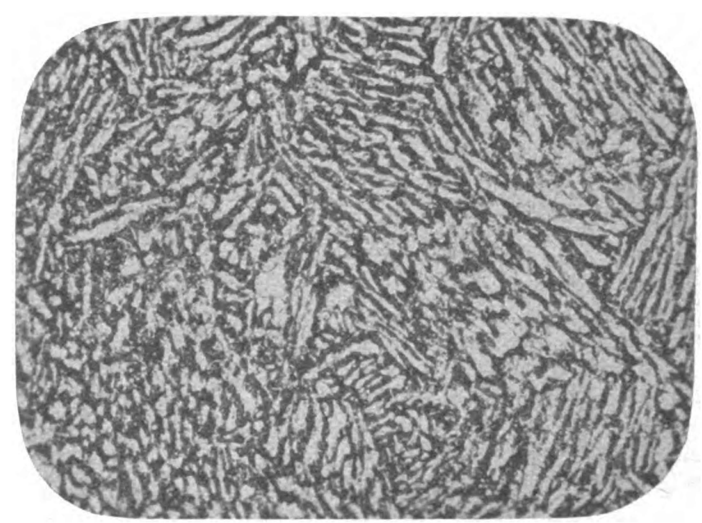

FIG. 669-4.—Magnification 100 diameters. Etching $NH_4OH+H_2O_2$. Remarks: Section taken from specimen 4, parallel to direction of forging.

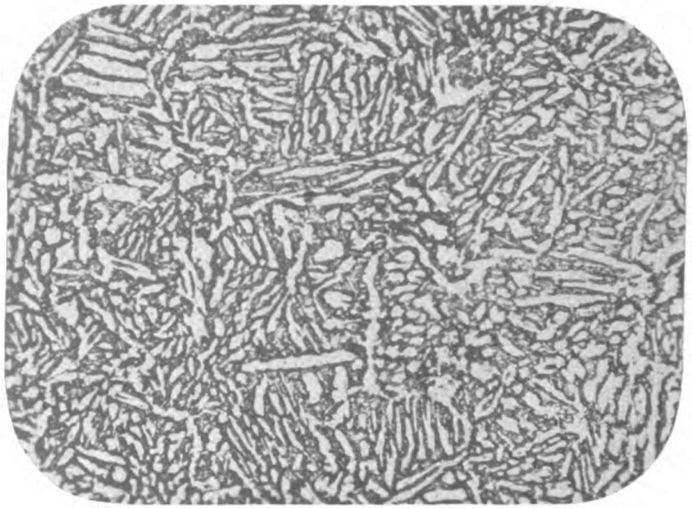

FIG. 669-5.—Magnification 100 diameters. Etching $NH_4OH+H_2O_2$. Remarks: Section taken from specimen 4 at right angles to direction of forging.

FIG. 669-6.—Magnification 100 diameters. Etching $NH_4OH+H_2O_2$. Remarks: Section from specimen 6. Structure typical cast gun metal. Dark cores of copper rich solution.

FIG. 669-7.—Magnification 100 diameters. Etching $NH_4OH+H_2O_2$. Remarks: Section from specimen 7. Cast gun metal.

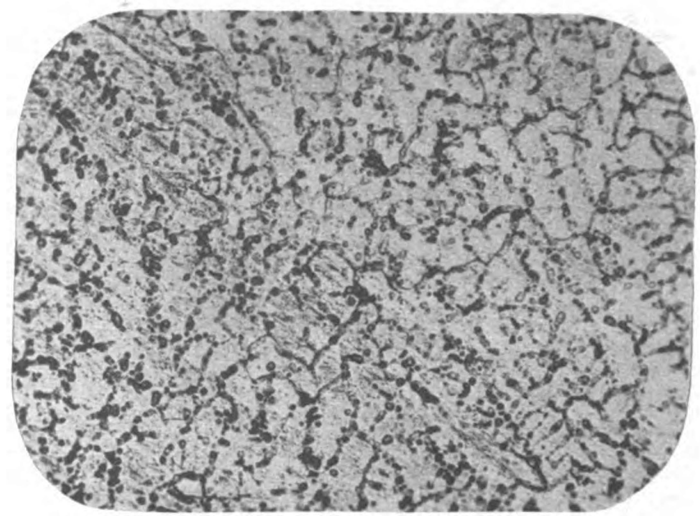

FIG. 669-8.—Magnification 100 diameters. Etching $NH_4OH+H_2O_2$. Remarks: Section from specimen 8. Lead and pits show dark.